POTASSIUM PLACEMENT IN CONSERVATION TILLAGE: CROPPING SYSTEM CONSIDERATIONS[1]

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Introduction

Soil fertility specialists have repeatedly observed that significant stratification of both P and K occurs on fields which are kept in no-till production, even if that time period is as short as three years. The actual degree of K stratification is affected by soil texture, the method of fertilizer application, crop rotation history, precipitation levels and surface residue management.

Potassium stratification isn't inherently deleterious to crop production in a given environment. Crop yield losses due to K stratification are less likely to occur if overall soil levels are high to begin with, and if drought doesn't limit K diffusion rates and/or root growth during critical uptake periods in crops like corn and soybeans. The most important recommendation regarding K fertility has generally been one of soil sampling at different depths if necessary to be aware of K distribution with depth. Fertilizer K recommendations are still based on the overall sampling depths of 0 to 6 or 0 to 8 inches, even if stratification has been very pronounced. Soil acidity changes with depth have thus far been considered a more important parameter to sample in long-term no-till fields.

Changes in K management approaches in conservational tillage programs need to assess the cropping system as a whole. Placement and rate are just two of the issues that are involved. Other significant factors in K management in conservation tillage include crop rotations, crop varieties, crop row widths, residue distribution, and planter design, as well as impacts of tillage systems on exchangeable K diffusion rate and K fractions other than exchangeable K. Some of these broader cropping systems are discussed to better understand the dynamics of K management in conservation tillage.

Banding Approaches

Until recently, a no-till producer's K application options were limited to broadcasting on the surface and(or) planter-band placement. Band application of K in starter (2" by 2") was observed to be superior to broadcast fertilization, especially under conditions where initial K fertility is low and(or) surface soil moisture is depleted because of either low rainfall or low residue levels (Yibirin et al., 1993). The review by Randall and Hoeft (1988) also concluded that corn yields increase with banding, relative to broadcast application, when K levels are low or during dry years. Two relevant considerations on salt injury to corn with starter-placed K are (a) that K rates are limited even more when urea is also present in the starter mixture and (b) that the muriate of potash form results in more salt injury than the sulphate of potash form when starter fertilizer is applied in furrow (Gordon, 1999).

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Equipment is now available to deep-band fertilizer with relatively minimum levels of soil and residue disturbance. The most interesting of these implements are those which combine deep banding and fall- or spring-strip tillage in one pass. Combing these two operations into one has efficiency advantages, and also provides an alternative to the extremes of no-till with no residue disturbance and full width, intensive tillage operations with little surface residue retention. Comprehensive studies in Iowa have reported significant corn yield advantages to deep-banded K even when soil test K levels were optimum or high (Bordoli and Mallarino, 1998; Mallarino et al., 1999). Corn yield increases were not necessarily associated with increased early growth or early uptake of K (Mallarino et al., 1999) and were more correlated with low soil moisture levels in late spring and early summer than with soil-test K (Bordoli and Mallarino, 1999). Minnesota studies involving ridge-till corn have also observed that deep placement of K in the center of ridges increases corn yields when overall K is deficient (Rehm, 1995).

In recent investigations in Ontario, corn yields on medium-testing stratified K soils after more than 6 years of no-till benefited more from starter application than from surface application or deep banding (Table 1). Responses to starter K were more pronounced in continuing no-till than when the previous no-till soils where fall zone-tilled or moldboard plowed.

Table 1. Corn yield response to fall and spring applied K in three tillage systems after long-term no-till at Kirkton, Ontario (average of 1996-98).

Tillage	Fall K Rate (lb/ac)	Application method	Yield (bu/ac) Low starter (0-9 lb/ac)		Yield (bu/ac) High starter (45-54 lb/ac)
No-till	0		148	**	161
	90	broadcast	155	*	161
Zone-till	0		149	*	157
	90	deep-band	153		155
Moldboard plow	0		158		162
	90	broadcast	164	**	170

*, ** Within-row yields separated by * and ** are statistically significant at P=0.05 and 0.01, respectively.

The range of responses to deep-band, starter-band and broadcast K application in different environments confirm the need for more research to establish when and where banded K would be more effective than broadcast K. Both custom applicators using fall strip-till units and farmers need to know more than we currently do about the merits of different placement options. Starter application while planting is not even an option for many corn farmers in states like

Indiana and Illinois since their planters aren't so equipped. Even fewer soybean planters can band dry or liquid fertilizer.

Narrow Row Soybeans

In corn-soybean rotations, attempts to band K for no-till corn - whether deep or shallow - inevitably raise questions about the availability of K to soybeans in the subsequent year. The concern is most relevant when soil-test K levels are low to medium, and perhaps less relevant when overall K levels are high to excessive. Although K bands are detectable via soil sampling in the year following application, higher soil K levels are often present near the former corn rows even after broadcast K application (Holanda et al., 1998; Varsa and Ebelhar, 1998). Potassium redeposition near the corn row - associated with K uptake, K leaching and(or) residue decomposition - may have detrimental impacts on subsequent soybeans in the interrows.

Recent research on the residual effects of K placement for corn on subsequent no-till soybeans illustrates some of the impacts that can occur on K concentrations in soybeans (Table 2). The actual impact on soybean yields is less clear, in part because of the compensatory nature of soybean growth.

Table 2. Effect of row position on soybean trifoliate K concentrations after corn near Paris and Kirkton, Ontario (1998-99).

Application Method for K to previous corn †	Leaf K concentration (%)								
	Paris 1998			Paris 1999			Kirkton 1999		
	In-row row		Between row	In-row		Between row	In-row		Between row
Deep Banding	2.07	**	1.62	1.74	**	1.14	2.07	*	1.71
Surface Broadcast	2.10	*	1.86	1.64	**	1.17	2.46	*	2.07
None	1.73	*	1.42	1.30	**	0.91	1.86	*	1.48

† K application totaled 90 lb ac^{-1} on low- to medium-testing K soils after 6 to 11 years of continuous no-till

*, ** Values within a row are significantly different at P=0.05 and P=0.01, respectively.

Detailed studies of the residual effects of K placement to corn on subsequent no-till soybeans are very important because of possible impacts on soybean disease susceptibility, yield and seed quality. Soybean response to K fertilizer directly, or in a residual manner after K application to previous corn, has not received the attention it deserves in the Corn Belt states. The traditional farm practice of K application before corn, but usually not before soybeans, also needs to be revisited because of the growth in no-till soybean acreage, the much higher levels of K removed via the seed relative to that after grain corn, and the possible extent of medium K testing soils in the region.

Hybrid Differences

Although soil-test K and soil moisture variables are the most important determinants of no-till corn responses to K application, corn hybrids can also vary in their response. Several reports have discussed hybrid differences in response to starter fertilizer application (which also usually involve P), but there is little information on differential hybrid response to banding versus broadcast K application in no-till corn.

In an initial trial in Ontario, we compared the response of five hybrids to application of 110 lb/ac of K_2O on a loam soil that ranged from 50 to 60 ppm in exchangeable K after 11 years of no-till production. The application methods (broadcast only, combination broadcast/band, and deep band) made no difference in ear-leaf K concentrations or final yield, but the yield increase associated with K application varied among hybrids and from year to year (Table 3).

Table 3. Corn hybrid response to K application, relative to zero K fertilizer, in long-term no-till fields near Paris, Ontario (1997-98).

Corn hybrid	Ear-leaf K (%)†		Yield increase (bu/ac)‡	
	1997	1998	1997	1998
DeKalb 385B	1.48	1.63	19	21
NK 3030	1.59	1.87	20	14
NK Max 357	2.00	2.19	22	1
Pioneer 3820	1.58	1.72	23	16
Pioneer 3893	1.51	1.84	5	11

† For the zero K plots, ear-leaf K concentrations averaged 1.0% in 1997 and 1.45% in 1998.

‡ Corn yields for zero K averaged 126 bu/ac in 1997 and 135 bu/ac in 1998.

Hybrid-specific K requirements are difficult to predict. From a scientific viewpoint, there is a lot of merit in understanding root dynamics and K uptake patterns relative to physiological development of hybrids. Banded placement might be more beneficial to certain hybrids whose root proliferation is restricted by adverse soil conditions. However, from a farmer's viewpoint resolving genetic interactions may be of limited usefulness due to the short commercial life-span of corn hybrids and the sheer numbers of hybrids available.

Tillage System Continuity

Concern for the effects of soil K stratification on corn or soybean response is really only an issue with continuous conservation tillage systems such as no-till or ridge-till. If farmers routinely alternate between no-till and deeper tillage operations - such as chisel or moldboard plowing - the issue of K placement is less of a management consideration. Potassium stratification with depth also occurs with chisel plowing repeatedly, but the gradient in concentration is generally less intense than with no-till.

Hill's survey (1998) demonstrated that the land area of Indiana and Illinois which is in rotational tillage was almost double that in continuous no-till. The typical pattern that was observed was no-till soybeans followed by conventionally-tilled corn. If fall zone tillage systems were to become more popular as an option for corn following soybeans, K stratification and placement considerations would become just as important as they have been for no-till or ridge-till corn. The key difference with the fall zone-till system is that it provides such an obvious approach to deep banding K with or without accompanying P and(or) anhydrous ammonia. But several questions remain to be answered, even with this system, for both corn and soybeans.

Summary

Potassium placement research in conservation tillage systems is difficult to do because of (a) soil variability in K levels and the degree of K stratification, (b) impact of soil texture, water holding capacity, soil temperature and precipitation levels on the results at any one site, (c) crop rotation and surface residue impacts on crop response to K fertilizer application, (d) possible differences among corn hybrid or soybean varieties in response to K, and (e) the myriad of options available for K placement. The cost of adequately documenting the soil and crop tissue K concentrations in experiments is also a challenge.

However, it is vital that K placement always be considered in the context of a whole cropping system. Tillage history is not the only relevant matter. Both direct responses of the crop as well as the indirect (i.e. residual) response of subsequent crops to K application options are important, especially if overall soil K levels are not very high.

Continued reliance on broadcast K application alone in long-term no-till or even mulch-tilled fields is not always satisfactory or efficient. Fall strip-till systems that can be combined with fertilizer banding have permitted new options to help address any detrimental impacts arising from K stratification after long-term conservation tillage. Despite the merits of deep-banding, traditional starter-band placement of K fertilizer is sometimes even more beneficial to corn yields than deep-banding alone in the row area after long-term no-till. Starter fertilizer placement of K increased corn yield most often on medium-testing K soils. Providing timely K fertility recommendations as tillage systems (whether continuous or "rotational") change in regions with different soils and cropping systems will be a challenge.

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